Case Study – Correcting Problem Control Values

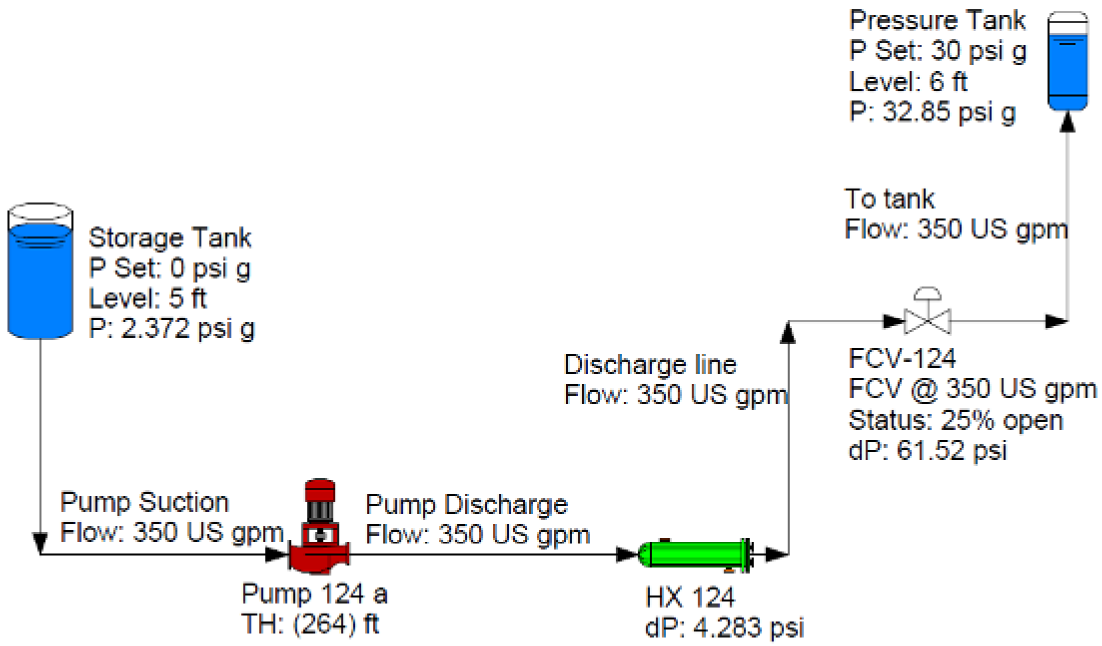
Piping systems are a collection of pumps, control valves, components, tanks and vessels. Often even the simplest piping system can present a large problem when it is not operating properly. In this example, we have a single pump circuit that pumps from a storage tank to a pressurized tank. A heat exchanger heats the process fluid, and a control valve regulates the flow rate into the pressurized tank to 350 gpm.

The maintenance engineer at this plant is experiencing problems with the control valve. It needs to be repaired every 10 to 12 months at a cost of $1,500 per repair. The maintenance engineer submitted a request to the project engineer to have the valve replaced with one more suitable for extreme service.

Before changing out the control valve, the project engineer wanted to get a good understanding of how the system worked. A model of the piping system was created and the system was analyzed using PIPE-FLO.

How the System Operates

The first step is to determine how the system is currently operating in an attempt to see why the control valve is failing, and more importantly to see if anything can be done to correct the problem.

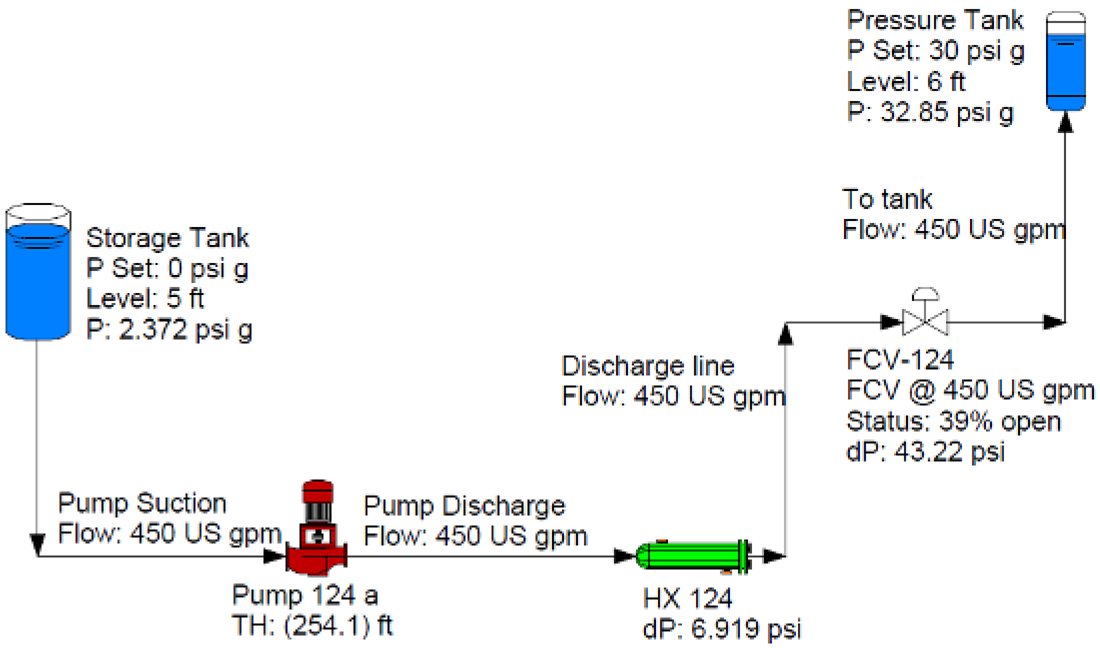


You can see that with 350 gpm going through the control valve there is a differential pressure across the valve of over 60 psi. This is a very high pressure drop for this control valve.You can also see that the valve position is 25% open.

After going out to the operating plant, the project engineer noticed the valve was controlling between 20-30% open and there was considerable noise from the valve. It appeared the valve was not sized properly for the application. After reviewing the original design calculations, it was discovered the pump was sized for 450 gpm vs. the 350 gpm it is currently set for, and a large Total Head safety margin was added during the pump selection process.

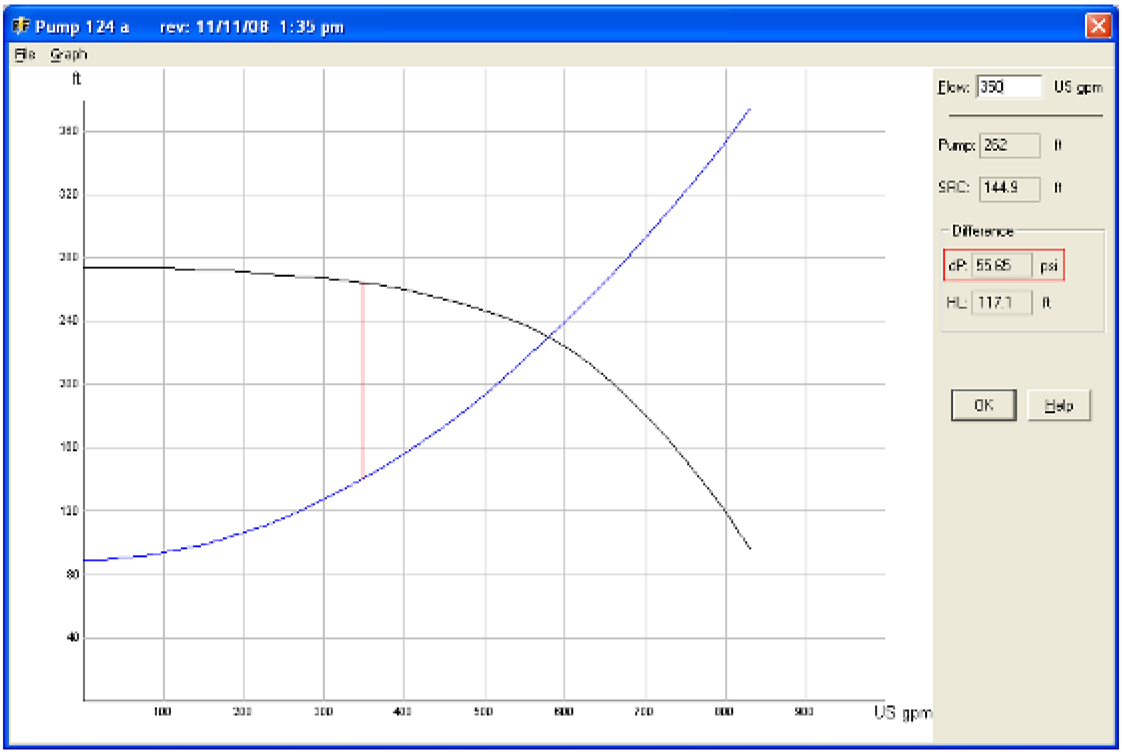
In reviewing the control valve sizing calculations the control valve was originally sized for 450 gpm with a differential pressure of 20 psi. A single port full-seated linear globe valve was selected. After modeling the system and inserting the control valve characteristics into the piping model, PIPE-FLO calculates the valve position to be 25% open. This is consistent with what was seen in the field.

If the set point of FCV-124 is changed to 450 gpm and a calculation is performed, PIPE-FLO determines the control valve is 39% open with over a 43 psi pressure drop.

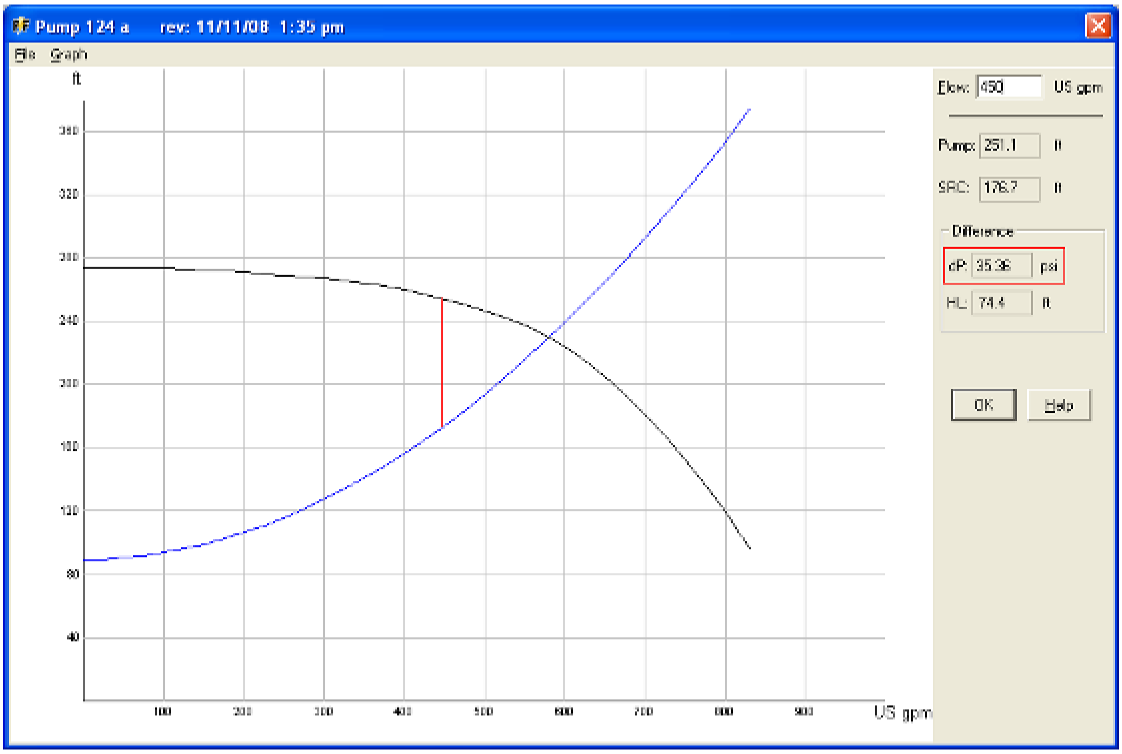


Displaying a System Resistance Curve

A system resistance curve displays the pump curve and the resistance curve for a single piping path on the same graph. It is an excellent way to visualize the operation of a simple system like this one.



Notice the difference in pressure between the pump curve and the system curve is over 55 psi. This difference must be made up at the control valve. Our selected globe valve must drop even more (over 61 psi) to limit the flow to 350 gpm.



Notice the required differential pressure this time is over 35 psi.As we saw earlier, our selected globe valve drops even more (over 43 psi) to limit the flow to 450 gpm.

So the pressure drop at 450 gpm even exceeds the design condition the valve was originally sized for (20 psi pressure drop at 450 gpm).

Correcting the Problem

When looking at the control valve using PIPE-FLO, the control valve position is calculated at 25% open with over 61 psi and 350 gpm through FCV-124. This corresponds to the field observations of the valve position. It appears there is more differential pressure across the control valve than it was originally sized for.

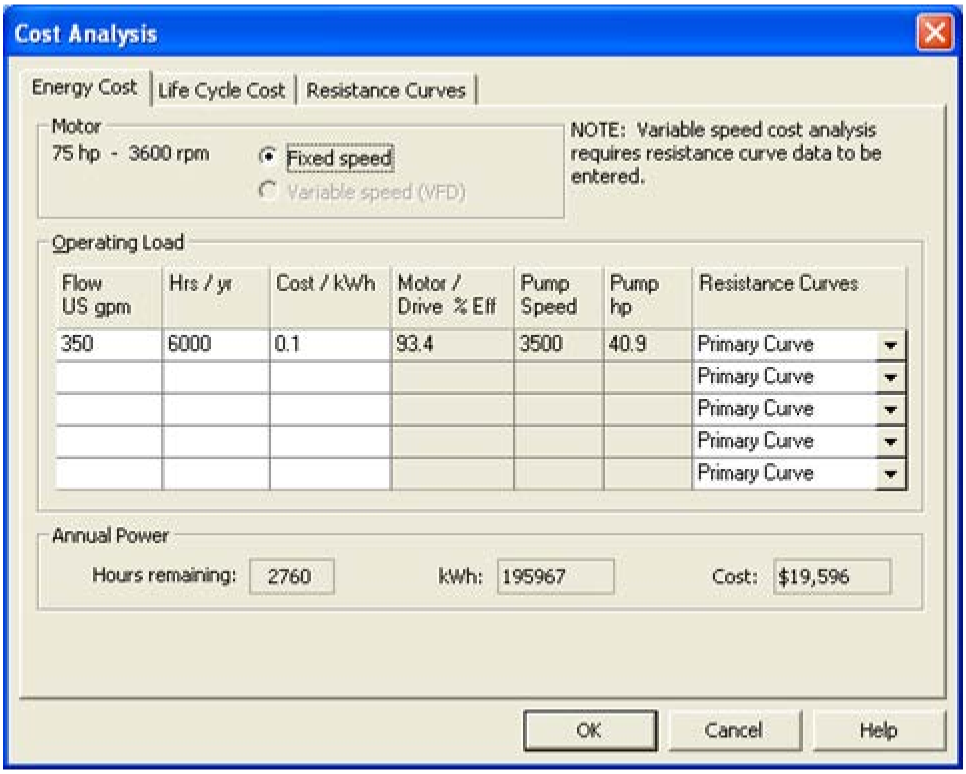
We have two options to correct the system:

- The control valve can be resized so that it can accommodate the higher-pressure drop with a valve position in a more desirable range for control.
- Trim the pump impeller so the pump does not develop as much total head, resulting in a lower pressure drop across the valve.

Resizing the control valve does not require extensive re-work of the pump impeller, so at first glance it seems to be the more attractive option. However, one issue to consider is that excessive differential pressure is still present across the control valve, and the extra head developed by the pump is wasted as noise and excessive turbulence. This increases both the pump operating cost and valve maintenance cost.

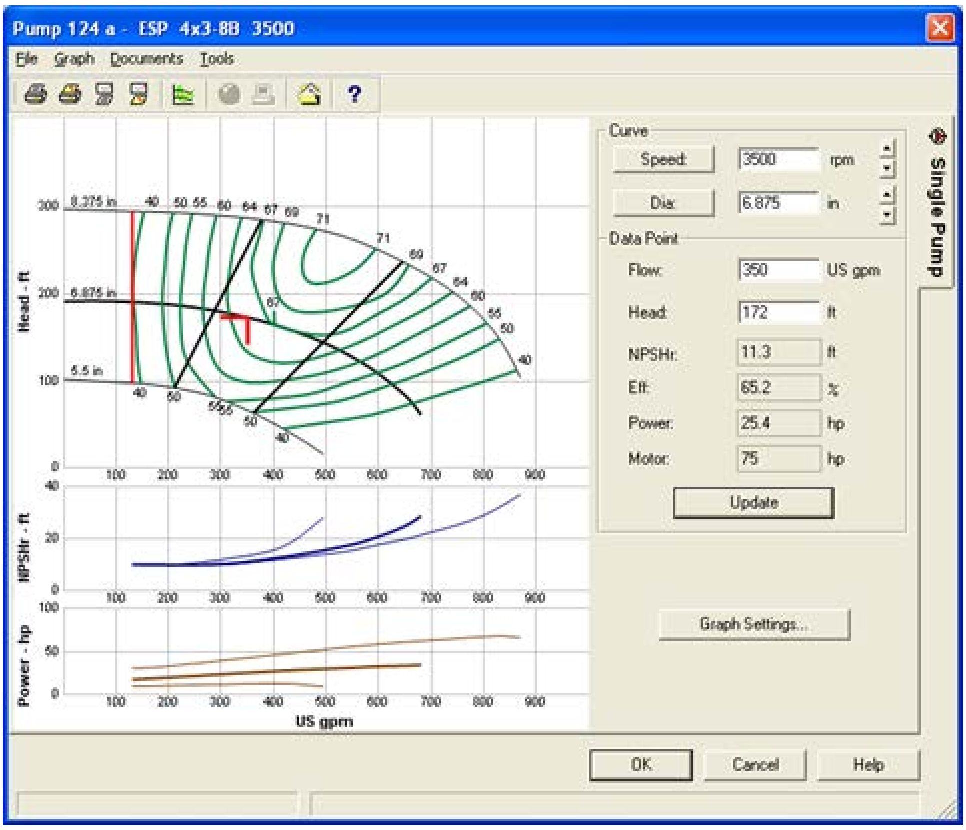
Evaluating Pump Changes

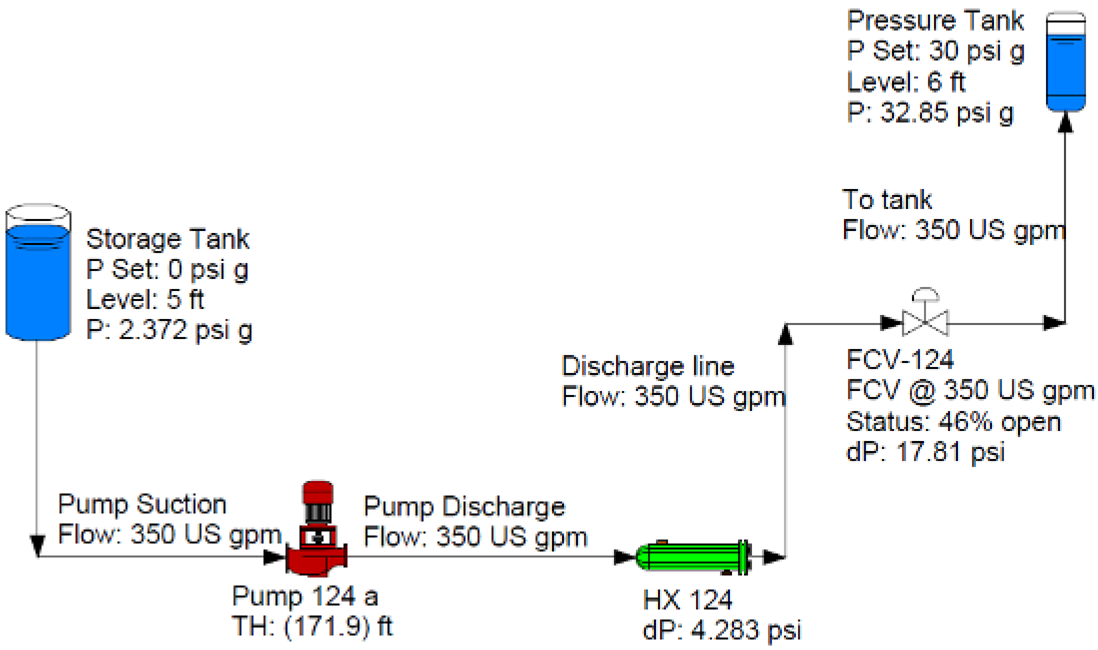
We will now focus on reducing the diameter of the pump impeller. This will save energy, but it will also require a new impeller if the pump is to run at 450 gpm in the future. To see how much energy can be saved we will need to run the cost analysis in the pump selection module.



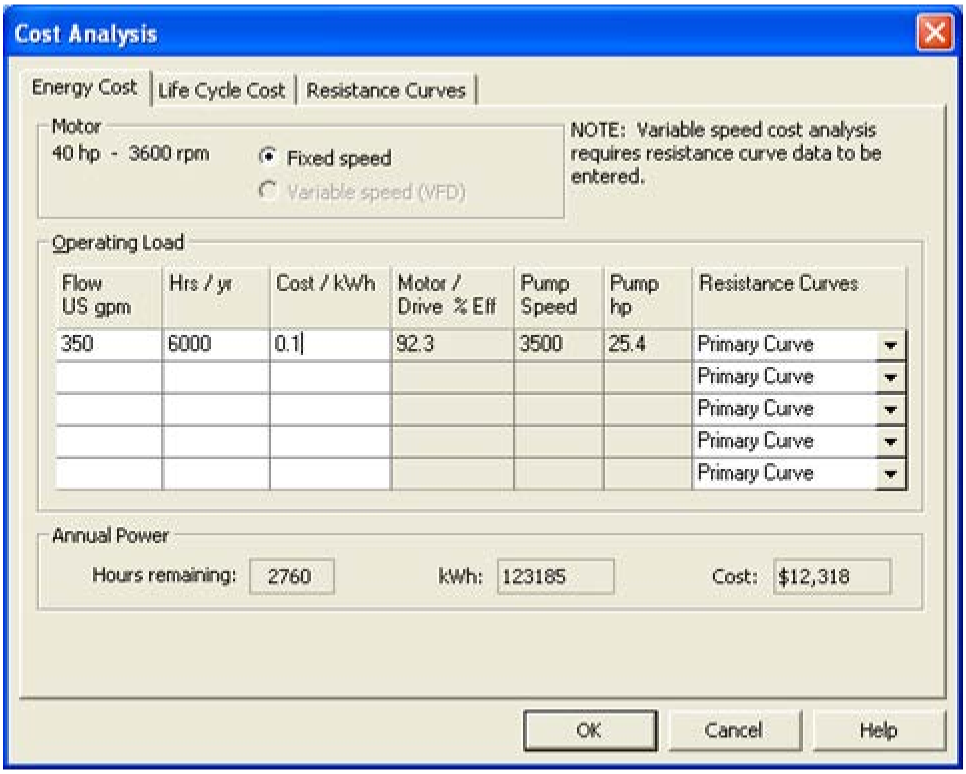
Notice the operating cost for this pump is $19,596 per year with an 8.125-inch diameter impeller.

Next we will see what happens if we trim the impeller to 6.875 inches.





At that diameter, there is approximately 18 psid across the control valve.



Notice the operating cost for PUMP 124a with the smaller impeller diameter is $12,318, or a savings of over $7,200 per year!

It costs approximately $3,000 to trim the impeller. In addition, it is estimated the cost to purchase a new impeller if the flow needs to be increased is around $2,500. The system changes were made and the control valve has been operating for over three years without the need for repair. The fact that the control valve no longer needs to be repaired increases the cost savings to over $8,500 per year.

Conclusion

As we saw in this example, the source of a problem is not often obvious. But with a clear view of how the system really operates, one can quickly identify the real source of the problem. More importantly, when the problem is known it is easier to arrive at the best solution.